

MASTER OF SCIENCE IN MECHANICAL ENGINEERING

NUMERICAL ANALYSIS OF HEAT EXCHANGER PERFORMANCE FOR A STAGGERED SHORT PIN-FIN ARRAY

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In this study, a 3-D finite-element based numerical simulation is used to model the heat transfer characteristics of a short staggered pin-fin array heat exchanger. The individual heat transfer contributions from the uncovered end wall and the pin-fins are investigated for various stream wise and span wise spacing configurations, and incorporated into a row-averaged heat transfer coefficient. A range of low Reynolds numbers were covered and the results corroborated with experimental data and assimilated to determine an area-averaged overall array heat transfer coefficient. The heat transfer performance is compared with the overall pressure drop characteristics to arrive at an optimal pin-fin configuration. The results of the study would find use in the design of a shroud enclosed micro-heat exchanger concept being proposed for turbine blade cooling.

KEYWORDS: Pin-Fin Array, Compact Heat Exchanger, Heat Transfer, Micro Heat Exchanger, Turbine Blade Cooling

FINITE ELEMENT MODELING OF METAL FOAM STRUCTURES SUBJECT TO COMPRESSIVE LOADING

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A unit-cell model was developed for open metallic foams in order to predict their effective elastic moduli and the plastic collapse strengths. The model is based on the metallic ligament frame of tetrakaidecahedral shape. The frame structure of the unit-cell was analyzed using the finite element method. The plastic collapse strength was determined when the joints of ligaments became plastic hinges under the assumption of elastic-perfectly plastic material behavior of the metallic material. Both elastic modulus and plastic collapse strength were computed using a single step of finite element analysis without any iterative or incremental procedure. In addition, a very small number of finite elements used. As a result, the unit-cell is computationally very efficient. The next study considered the effective elastic moduli and plastic collapse strengths of the same metallic foams filled with a viscoelastic material. For this study, the unit-cell model was modified. The model considered the ligament frame structure supported by viscoelastic foundation that represented the filler material. In order to validate the unit-cell models, experiments were also conducted. The experimental data agreed very well with the predicted values of both stiffness and strength.

KEYWORDS: Aluminum Metal Foam, Metal Foam Compressive Loading, Composite Metal Foam, Metal Foam Stiffness, Metal Foam Strength

MECHANICAL ENGINEERING

A COUPLED HYDRODYNAMIC/STRUCTURAL MODEL FOR SHIP/RAMP/BARGE INTERFACE

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A mathematical model describing the fundamental dynamics in the interface problem between a ship, a barge, and a connecting ramp is developed and solved. The hydrodynamics for the ship and the barge are described by a 12-degree of freedom fully coupled model, which is based on potential theory and incorporates proximity effects. Ramp structural dynamics are studied by a finite element model, which has been calibrated based on detailed studies of commercially available codes. The models were coupled together through a spring/damper and the solution of the system was obtained in both regular waves and a representative sea state. Parametric studies with regards to different coupling conditions indicate that optimization based on either relative motions or ramp maximum stress is possible.

KEYWORDS: Hydrodynamic model, RORO, Roll-On Roll-Off, RRDF, CAPE-T, CAPE-H, CAPE-D, WAMIT, RRDF, Structural Model, Finite Element Model, Ramp, Coupling, Barge

INVESTIGATION OF WAVE MOTION EFFECTS ON THE NUSC 21UUV THROUGH SIMULATION

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The continued emphasis of naval operations in the littorals requires the further research and development of low cost, tetherless autonomous vehicles. The littoral environment is a highly dynamic region that asserts a complex problem and challenging motion control for autonomous vehicles.

The main objective of this thesis is to understand the relative importance of the wave induced fluid velocities and accelerations on slow speed AUVs. These Froude-Kriloff accelerations caused by the wave excitation are compared with changes in buoyancy, wave amplitude, center of gravity, and wave direction. The magnitudes of the Froude-Kriloff accelerations were compared to the other body-fixed accelerations to determine the relative significance of these accelerations. The results are produced by utilization of a simulation model. Through this research a better understanding of the 21UUV operational capabilities was achieved.

KEYWORDS: Autonomous Underwater Vehicles, Control Systems, Froude-Kriloff, Robotics

THERMOMECHANICAL CYCLING OF FLIP CHIP SOLDER JOINTS WITH AND WITHOUT UNDERFILL ENCAPSULANT

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Flip chip solder joints with underfill encapsulants can undergo cyclical thermal stresses and strains corresponding to power on-off cycling of equipment. To simulate this, the stress-strain hysteresis behavior of 63Sn/37Pb eutectic solder joints with two different underfills was determined experimentally during thermomechanical cycling. The thermomechanical loading was applied using a bimetallic loading frame, which was thermally cycled over a temperature range of 30 to 140 degrees C. Each thermal cycle followed a waveform comprising a 15-minute heating time and a 21-minute cooling time. Each sample was cycled a

total of 50 times. By comparing the results of the experiments with and without underfill encapsulant, the impact of the constraint imposed on the solder joint by the underfill was evaluated.

KEYWORDS: Underfill, Flip Chip, Solder Joints, Thermomechanical Fatigue

